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UNITED STATES NAVY

MEDICAL NEWS LETTER

Season's Greetings

As this year passes and takes its place in the annals of history, our thoughts turn to the message which the season represents but which mankind finds so difficult to embrace - "peace and goodwill to all men."

Our Nation's determination to advance the cause of peace calls for heavy burdens to be borne by many members of our Armed Forces. I am not unmindful of the daily sacrifices you have made during this year which is about to pass. All of you have labored hard and long; some at the bed-side of the sick and injured to ease the pain of the stricken; some in research seeking knowledge to aid your fellowmen; some have stood guard in far-away places separated from loved ones. These are commendable deeds for each is contributing to a better world in which to live.

The relief of suffering has always been a noble profession. The prevention of disease and restoration of health are among our greatest rewards for the years of study and toil in all the medical and para-medical specialties and allied sciences. It is a profession born of need and dedicated to the betterment of mankind. It is especially fitting to consider these thoughts in connection with the Christmas Season which is a time for spiritual reflection, healing of the human spirit, and restoration of hope and love in mankind.

With confidence in your continued support and in your zealous endeavors wherever duty calls, I extend to each of you my sincere best wishes for a holy and joyful Christmas and my hope that your blessings will be bountiful in the coming New Year.

Edward C. Kenney

EDWARD C. KENNEY,
Rear Admiral, MC, USN
Surgeon General

United States Navy

MEDICAL NEWS LETTER

Vol. 42 Friday, 20 December 1963 No. 12

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The issuance of this publication approved by the Secretary of the Navy on 28 June 1961.

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—Editor

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Individual Patterns of Urinary 17-Ketosteroid Fractions *

For many years there has been interest in the individuality of man. The contributory factors that make one person different from another are numerous and relatively poorly understood. In addition to the hereditary and environmental forces that play an important part in shaping the mental and physical aspects of a personality, there are also physiologic factors. Some persons have more energy and zest than others; some tend to be thin, others to be fat; some react differently to stresses from others. Because the adrenal cortices play a major role in response to stress, information regarding individual variations in adrenocortical function might contribute to an understanding of the possible influence of these glands on the general physiologic pattern that characterizes each person.

Fractionations of 17-ketosteroids in 24-hour urine collections of six normal women and of seventeen with varying degrees of hirsutism or ovarian dysfunction indicate that each individual tends to have a characteristic level of excretion of each fraction and a reproducible pattern of excretion of these fractions in the unstressed state, but significant variations of pattern occur between normal subjects as well as between patients. In response to a single standard dose of ACTH, individual differences in steroid metabolism are frequently accentuated, with a tendency for the greatest increases in excretion to occur in fractions whose excretions were relatively high initially. In some subjects, marked differences in responses of 17-ketosteroid fractions occurred with similar rises in excretion of cortisol metabolites; whereas in others, differences in responses of cortisol metabolite excretion also were seen.

With the ingestion of hydrocortisone in a dosage that only partly suppressed endogenous ACTH, variations in the rate and extent of fall in excretion of the individual 17-ketosteroid fractions were observed; the dehydroepiandrosterone fraction tended to fall more rapidly than androsterone or etiocholanolone, and the changes sometimes required several weeks to reach a new stable level. These observations indicate that in some persons the level of ACTH, either endogenous or exogenous, may significantly affect the pattern of steroid excretion as well as the total quantity of steroids excreted. They raise interesting questions regarding possible clinical implications.

Comments. The authors' approach to a problem usually reported as a laboratory study is an interesting departure from the conventional report. This article directs attention to the concept—or point of view—of the individuality of man, that each human being is a unique biologic specimen and has a characteristic (his own) pattern of response to his environmental stresses. Just as responses to stress in the disease state (patients) vary, so do responses among normal subjects. These scientists, disciplined in laboratory methods,

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* William McK. Jefferies, and Andrew M. Michelakis, Dept of Medicine, Western Reserve University School of Medicine, and The Infertility Clinic of the Maternal Health Association of Cleveland. Metabolism XII, November 1963

are obviously attuned to important basic concepts relating to personal identity and unity of the organism. This approach is an admirable and welcome contribution to the medical literature. —Editor

(Adapted from a letter and article review forwarded to the Medical News Letter by CAPT George L. Calvy MC USN, CO, Naval Medical Field Research Laboratory, Camp Lejeune, N. C., 30 October 1963.)

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Factors Determining Serum Lipid Concentrations *

William R. Harlan Jr, Robert K. Osborne, and Ashton Graybiel, U. S. Naval School of Aviation Medicine, U. S. Naval Aviation Medical Center, Pensacola, Fla.

Serum lipids are related to the geographic prevalence of coronary artery disease and the presence in individuals of manifestations of this disease. In recent years, ample confirmation has been provided for this relationship, and both cholesterol and triglyceride have been implicated. However, little information has evolved which would indicate the cause of these elevated serum lipid levels. It has become very important to determine what factors, hereditary or environmental, may influence lipid levels. Age has been shown to be a significant factor with both serum cholesterol and triglyceride levels demonstrating a linear rise with advancing age. For this reason, investigation of factors relating to elevations should be initiated early in life and carried forward to determine what factors may influence this rise. Only in this manner can environmental factors be separated from, and evaluated along with, genetic factors. As a part of a longitudinal study of a group of young healthy men, serum cholesterol and lipoproteins have been measured and their relationships to age, weight gain, somatotype, and family history investigated.

The Thousand Aviator Study has previously been described in detail, including composition of the group and methodology; only features pertinent to the present report receive comment. When initially studied in 1940, each member was at an optimal weight as judged by the Metropolitan Life Tables. Somatotyping was performed (by Drs W. H. Sheldon and Albert Damon) at that time and should represent an accurate estimate of body type inasmuch as salient body features were not obscured by aging or obesity. During the next 18 years, the group followed the usual course of American males with a transition from active youth into sedentary corpulent middle age. In 1958, fasting serum cholesterol and lipoprotein measurements were obtained on 475 of the subjects. Cholesterol was determined by the method of Abell, et al, and the lipoprotein measurements determined at the Institute of Medical Physics,

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* Bureau of Medicine and Surgery Research Project: MR 005.13-3001 Subtask 2 Report No. 8, released by CAPT Clifford P. Phoebus MC USN, CO, U. S. Naval School of Aviation Medicine, 9 September 1963.

utilizing the technic described by de Lalla and Gofman. During the 1958 evaluation, careful attention was given to obtaining the family history of vascular disease.

With these considerations in mind and in spite of the limited aspect of the present data, several conclusions seemed warranted. Increase in weight (or adiposity) was associated with higher levels of very low density lipoproteins and triglyceride. A similar relationship to a positive family history of vascular disease was found. Somatotype per se did not appear to play as important a role in determining serum lipid concentration. Differences in cholesterol were less impressive, and examination of the lipoprotein pattern suggested that these differences may be secondary to alterations in triglyceride. Complete evaluation of all pertinent factors should provide further insight into factors affecting serum lipids.

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Eye Manifestations of Thyroid Disease

LCDR George B. Magruder MC USNR*. Proceedings of the Monthly Staff Meetings of the U. S. Naval Hospital, NNMC, Bethesda, Md., 1962 - 1963.

The association of various ocular signs with thyroid disease has been reported for more than one hundred years. In spite of intensive study and experimentation over this long period, the specific cause of these interrelated changes remains obscure, and therapy—particularly in severe cases which might lead to loss of vision or of the eye itself—is unsatisfactory.

Several attempts have been made to classify the type of ocular findings associated with thyrotoxicosis. Mulvaney has been the proponent of the idea of two basic types. One was the thyrotoxic form, the most common and mild occurrence of lid retraction and of exophthalmos associated with the classic Graves disease. The second was his "thyrotropic" form, the "malignant," progressive, or hyperophthalmopathic form of the disease which usually occurred in the less severe form or even in the absence of thyrotoxicosis.

Means was the proponent of the unitarian concept of the disease. He thought there were certain phases of the same basic process and described three types: (1) classic Graves disease with ophthalmopathy, thyrotoxicosis, and goiter; (2) Graves disease with thyrotoxicosis but without ophthalmopathy; and (3) hyperophthalmopathic, or malignant, Graves disease with hyper-, eu-, or hypothyroidism.

Most workers now agree that separation of the three types into distinct and exclusive groups is arbitrary and cannot be supported on clinical grounds. Several findings support this concept. Among them is the marked variability in signs, onset, course, and prognosis in various cases of patients with the

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* Doctor Magruder was formerly on the staff of the Ophthalmology Service, USNH, Bethesda, Md.

disease. Some findings, such as lid retraction, occur in as high a percentage of patients with thyrotoxic and thyrotropic forms. Analysis of exophthalmometer measurements shows a normal distribution which implies classification in a single population. Measurements of the removal rate of radiosodium from orbital fat in these patients has also failed to give evidence of two distinct groups. Experimentally, one can produce all of the various types of ocular change without varying the method of production, indicating the differences to be of degree and not of nature.

Clinically, one may look for many ocular changes and signs. Day gathered together nineteen different signs that had been described by name. Most of them are of academic interest only, and the writer discusses only a few which may be clinically important.

Proptosis. A commonly associated finding, proptosis is believed by many to be the most important; it is thought that a measurement of this is all that is needed to follow the disease. Most investigators have found that proptosis, considered by itself, is by far not the most important functional finding, and that whether this increases or decreases with or without therapy is much less important as far as the patient's symptoms go than other signs discussed in this review.

The proptosis is usually straight forward, rather than up or down or to the side as would appear in the case of a tumor. The condition is due to increased volume of orbital contents—in some cases, mostly edema and in others, mostly fat. Most often, it is bilateral and usually somewhat asymmetrical with one eye varying 2 to 4 mm from the other. Usually, it is measured by an exophthalmometer—most frequently the Hertel type—which uses the lateral wall of the orbit as a point of reference and measures the distance from this anterior portion of the wall to the cornea in millimeters; the eyes thus can be compared. The absolute values are variable because of variation of lateral bony orbital walls and dephths of orbits in various facial types. A difference of more than 2 mm in the two eyes is usually considered to be significant.

Lid Retraction. This definite sign actually is the most common and frequently the first sign of endocrine exophthalmos; it occurs in 80% to 90% of persons with Graves disease. In the past, it has been confused with proptosis itself since it was thought that the lid was high because of the proptosis. Lid retraction is characterized by a high and deep lid fold, and is due to a shortened levator muscle of the upper lid. The occurrence of unilateral lid retraction has created some interest in the past and several groups of patients with this condition, but without exophthalmos, have been reported in the literature. It was found that many of these patients go on to develop overt signs of thyrotoxicosis later; it was also found that a high percentage of them had a positive Werner or T-3 suppression test which revealed an endocrine abnormality.

All patients with this finding, seen now by the writer, are subjected to intensive evaluation of thyroid function; it is particularly important to do

this because many patients are referred initially with the diagnosis of orbital tumor. This isolated finding of lid retraction allowed some interesting studies as to the cause. A part of the levator muscle is under sympathetic control via the third nerve; it was postulated that increased sympathetic innervation might account for this. Neosynephrine 10% will produce lid retraction in the normal patient but also dilates the pupil. A stellate ganglion block will cause a Horner's syndrome on the side which manifests ptosis, but the increased lid fold in instances of lid retraction is unchanged by this. Electromyography has shown no increased activity in the levator muscle in these patients. The retraction is unchanged also by retrobulbar block and remains present during sleep and anesthesia. The exact cause is unknown but is undoubtedly contained within the muscle itself; the change in the muscle is reversible since the retraction responds usually to antithyroid therapy.

Lid Lag. This condition is thought to be the result of lid retraction. It is looked for quite routinely and is a good sign if the examination is properly performed. This will be manifested by many patients when they stare fixedly at an up-and-down moving object. One must be sure the patient is relaxed and also the examination must be performed several times to be sure there is true lid lag.

Fullness of Upper Lid. A non-pitting fullness, particularly in the upper lid is more often associated with the more severe form of the disease. This is the most frequent cause of cosmetic complaint by the patient.

Conjunctival Injection. A characteristic sign in that there is dilatation of the conjunctival blood vessels over the insertions of the recti muscles onto the globe—this condition is most common laterally but may also be observed medially. The cause is not known. However, radiosodium studies have not shown passive congestion.

Limitation of Extraocular Movement. This is a common and characteristic finding. The condition is not usually an isolated muscle paralysis, but rather is manifested first as inability to elevate the globe and to look up, and later as limitation of lateral movement. The globes may become fixed in depression and cannot, even forcibly, be altered. This imbalance causes diplopia, of course, and is frequently the most distressing problem to the patient. The limitation is rarely symmetrical and, therefore, the cosmetic appearance of misaligned eyes may be quite apparent. The patient usually can learn to suppress the vision of one eye and frequently this bad cosmetic appearance becomes more important to them than double vision. Electromyography shows mostly a neurogenic type paresis rather than a myopathic one.

Chemosis. In this common finding, the conjunctiva first appears to be glassy then water-logged and boggy; frank chemosis appears, sometimes with actual prolapse of the conjunctiva through the palbebral fissure and a resultant drying and crusting.

Although modes of onset of the signs vary widely, the typical onset with Graves disease is one of mild chemosis, lid retraction, and some degree of exophthalmos which may increase somewhat. In a large majority of cases, this is the extent of the eye problem; signs and symptoms resolve or improve markedly after therapy for the thyrotoxicosis. Less frequently, the ocular signs are minimal before treatment, then progress and cause trouble after treatment. This type usually improves with time but can be markedly progressive with exophthalmos which pushes the globe out so that the corneas are exposed to the air with resultant drying, ulceration, and infection—perhaps with perforation and loss of the eye. The conjunctivae may also be prolapsed at this stage. Pressure on the optic nerve may cause optic atrophy. Glaucoma may occur from the orbital pressure. This is the picture of "malignant exophthalmos" which is, of course, a misnomer but is used to denote the relentless nature of the process.

One recent report of the incidence of eye signs in thyrotoxicosis was that of Shultz and co-workers at Iowa in 1960. They reported 165 patients with thyrotoxicosis at the thyroid clinic who had been selected only because of their thyrotoxicosis. Of the 165 patients, 110 had eye signs other than proptosis; 82 had lid retraction which disappeared in 56 cases after I^{131} therapy; in 23 others, there was some residual. Only 3 had no improvement. Sixty-seven patients had periorbital edema of which 45 cases cleared after treatment; 15 had a residual and only 7 had no improvement. There were 23 with ophthalmoplegia of which 11 cleared after therapy; 8 were left with some residual, and 4 showed no improvement.

In Table 1, symptoms are added to the previously noted signs; 120 of the 165 patients had signs plus symptoms, 55 cases of which disappeared (46%). Part B of Table 1 shows the fate of proptosis after therapy. In the 120 patients with signs and symptoms, the proptosis decreased in 10, remained the same in 32, and increased in 78 cases (65%). Of the 45 patients without ocular signs or symptoms, the proptosis decreased in 2, remained the same in 36, and increased in 7 cases (16%).

There were several other interesting figures in this study. While only 9% of patients retained significant signs or symptoms, the proptosis was the same or increased in 91% after treatment; 50% of patients showed increase in proptosis after I^{131} therapy. Therefore, proptosis in itself should not be used as the sole index of severity because it is frequently an asymptomatic component. Fourteen percent of patients had ophthalmoplegia, and a significant number of these had associated skeletal myopathy. Fifty percent of these returned to normal after therapy. Three percent (5 patients) had pretibial myxedema and all had significant ocular disability which progressed after I^{131} therapy. The association, then, of pretibial myxedema with ocular signs can be a very important prognostic sign.

Proptosis in itself should not be used as the sole index of severity because it is frequently an asymptomatic component. The study showed that 14% of patients had ophthalmoplegia and that a significant number of these had associated skeletal myopathy; 50% of these returned to normal after therapy. Three percent (5 patients) had pretibial myxedema and all had significant

ocular disability which progressed after I^{131} therapy. The association then of pretibial myxedema with ocular signs can be a very important prognostic sign.

Table 1

Effects of I^{131} on Endocrine Ocular Lesions in 165 Patients With Thyrotoxicosis

A. Signs and Symptoms Following I^{131} Therapy

Sign/symptom	Disappeared	Residual	No Improvement
120 Patients with signs of: Lid retraction) Periorbital edema) Ophthalmoplegia) Symptoms)	55 (46%)	58 (48%)	7 (6%)

10 patients had symptoms but no signs. (6%).

B. Proptosis Following I^{131} Therapy

Patients	Decreased	Same	Increased
120 Patients with ocular signs and symptoms	10 (8%)	32 (27%)	78 (65%)
45 Patients with no ocular signs nor symptoms	2 (4%)	36 (80%)	7 (16%)

It can be said, then, that in about 75% of patients with Graves disease, ocular signs will be present, about one-third of these will have clinical significance, of which a tenth will be serious and will require therapy. But in 90% of patients the troublesome symptoms and signs will disappear after treatment of the thyrotoxicosis.

Pathologically, in these mild cases, the extraocular muscles are grossly of normal size but contain double the normal amount of fat. There is also atrophy of fibers with loss of striation and amorphous granulation of the sarcoplasm. The orbit has also an increased amount of fat. In more severe cases, there may be a tremendous increase in size of the extraocular muscles with marked edema of the orbit, increase in mucin content, fibrosis of all tissues, and inflammation and degeneration of the extraocular muscles

later. There may also be a marked increase in lymphocytic infiltration in this tissue and some workers wondered if this could have accounted for the favorable reports after irradiation since this tissue is radiosensitive.

One is in the dark as to the cause of these orbital changes. An interesting experiment reported recently was that of McGill and Asper who explored the theory that autoantibodies may play some role in the orbital changes. This was based on the facts that there is predominance of monocytes in both orbit and thyroid gland in these cases, and that thyrotoxicosis with proptosis has a higher titer of antithyroglobulin than thyrotoxicosis without proptosis; some cases of malignant exophthalmos had been reported in association with an autoimmune disease, Hashimoto's struma. McGill and Asper were unable to show by direct or indirect fluorescent antibody technics any evidence of the role of antibodies in the orbit.

The treatment of endocrine exophthalmos, in general, remains unsatisfactory. The best treatment is prevention, of course, and though no definite prediction can be made as to which patient will develop progressive signs and symptoms, there are several clues. One is the presence of severe and progressive changes before therapy since it is known there is commonly some progression of proptosis, at least, after therapy in these cases. Also, the presence of pretibial myxedema should make one wary and cause one to proceed slowly with therapy of the thyrotoxicosis.

Several types of supportive therapy are helpful. One is elevation of the head of the bed on blocks to decrease edema. Diuretics are also of value but on a short-term basis. For symptoms of corneal exposure, lubricating drops may be used and even moisture shields on eyeglasses. If constant corneal exposure is encountered, temporary tarsorrhaphy, or suturing the lids together can be performed. Diplopia is usually treated by placing a patch over one eye. Many workers have reported at least temporary improvement in edema and chemosis from high dosages of corticosteroids, sometimes in the range of 800 mgm of cortisone per day or the equivalent.

In consideration of the more drastic forms of therapy, such as decompression of the orbit, radiation of the orbit, and various maneuvers directed at the pituitary gland, most workers agree that definite signs of progressive disease over a long period of time with ophthalmoplegia and corneal exposure, problems should be present; or imminent danger of loss of vision from pressure on the optic nerve, or glaucoma. For these cases, irradiation of the orbit alone, the pituitary alone, or both together, has been tried. Hypophysectomy and pituitary stalk section has also been performed. Results of the procedures are reported to be good at some centers and equivocal in others. It has been reported that the maximum response from irradiation may not occur for several months after treatment. This makes the results difficult to evaluate since spontaneous improvement may occur over this time.

The writer's experience at the U. S. Naval Hospital in pituitary and orbital irradiation is limited. However, his personal experience with several cases which underwent hypophysectomy by Dr. Bronson Ray at Cornell was that many showed no progression after surgery, although only a few showed improvement.

The writer discussed a disconcerting case. A patient who had been treated for toxicosis had a hypophysectomy for a markedly progressive unilateral exophthalmos and there was moderate improvement. Two and a half years later, the patient suffered acute onset of marked exophthalmos in the other, and formerly unaffected, eye. At this time, there was no evidence by all available testing of any pituitary function. The patient later was treated with orbital decompression with a fair result. No good explanation has been given for the appearance of severe endocrine exophthalmos in this person who was without a pituitary gland.

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Renal Scans in Urologic Diagnosis Using Neohydrin Hg-203

LT R. Teryl Brooks Jr, MC USN*. Proceedings of the Monthly Staff Meetings of the U. S. Naval Hospital, NNMC, Bethesda, Md., 1962 - 1963.

Use of radioisotope scintillation scanning of body organs, thyroid, liver, and brain has become an established diagnostic test within the past decade. This procedure is now gaining wide interest in the area of urological and medical renal diseases and is in the stage of investigation for evaluation of its usefulness in clinical urology. This preliminary report outlines the results of renal scans performed on 120 patients whose illnesses represent a wide variety of renal diseases. The selection of patients was intentionally broad in order to determine in what areas scanning might produce useful information.

Method

No prediagnostic preparation of the patient is needed other than intravenous injection of 50 cc of neohydrin Hg-203 one to three hours prior to scanning. The patient is placed in a prone position and scanning of the renal areas is accomplished automatically by the scanning machine. Since radioactive mercury is trapped temporarily within the renal tubular cells, the activity is present wherever functioning renal tissue exists. Approximately 30 minutes is required to scan the entire renal area. The detector "sees" an area smaller than one cm in diameter at any one time. Two recordings of the distribution of radioactive materials are made simultaneously by two different methods. The first is by a series of dot recordings by a marking device onto electrically sensitive paper in synchronization with the motion of the detector, and shows the areas of greatest radioisotope activity by clustered dots. This picture can be seen as it takes shape during the scanning and is used in monitoring the procedure.

The second method is by photorecording the image onto photographic film. In the process, the light source and detector move simultaneously;

the intensity of light varies with the amount of activity detected. Highest activity increases the intensity and darkens the film. Distribution of the Hg-203 delineates the image of the kidney parenchyma.

Results

The 120 patients are grouped by diagnostic indications for scanning (Table 1). The total figure exceeds the total number of patients due to more than one complaint for some patients.

Table 1

Diagnostic Indications for Scanning

	Cases
Hypertention	38
Medical renal disease	38
Intrinsic renal mass	25
Non-functioning kidney	13
Iodine sensitivity	6
Extrinsic renal mass	4
Normal	4
Total	128

The author showed an example of a normal renal scan representing one of the 4 controls in the series of patients who had normal excretory urograms and no known renal disease. Here it is well to note the activity in the hepatic region and the incidental disclosure that the left kidney is lower than the right.

Table 2

Patients with Known Iodine Sensitivity

	Cases
Hypertension	3
Pyelonephritis	1
Tumor survey	1
Pelvic surgery	1
Total	6

The scan has proven valuable in the group with known iodine sensitivity (Tab 2). It was performed in three cases because of hypertension and helped to rule out a renal etiology. A fourth case manifested known functional impairment bilaterally due to chronic pyelonephritis and this was confirmed by the scan. In another case, the patient was scanned to evaluate the possibility of the kidney as a source of metastatic tumor. The normal scan was confirmed by retrograde pyelograms.

Case 1. As an example of this group, the sixth case was a 41-year old Caucasian woman with a history of pyelonephritis. Excretory urograms were

performed at another hospital prior to this admission and produced a severe allergic reaction by the patient. The photoscan obtained before pelvic surgery pictured a horseshoe kidney.

Table 3

Results of Scanning for Suspected Intrinsic Renal Masses

Abnormal scan	13
Simple cyst	6
Renal carcinoma	4
Polycystic disease	3
Normal scan	12
No mass	10
Simple cyst (false negatives)	2
Total	25

Renal scans were obtained in 25 cases with suspected intrinsic renal masses. The interpretations of these scans are outlined in Table 3. Both cases of false negatives were large cysts on the surface of the kidney which produced no calyceal distortion. The masses were apparent on soft tissue X-ray studies and subsequently proven by surgery.

Case 2. A 65-year old Caucasian man was evaluated for a left upper quadrant abdominal mass. He had no urinary complaints; the urinalysis was negative. Excretory urograms revealed the mass was at the superior pole of the left kidney. The scan disclosed a large rounded defect in the upper pole of the kidney with downward displacement of the kidney. Surgical exploration showed a large single cyst of the left kidney.

Case 3. A 35-year old Caucasian woman had manifested recurring hematuria for 18 months. The excretory urograms suggested a space occupying lesion in the lower pole of the left kidney, and distortion of the pyelocalceal pattern. The scan demonstrated a defect in the same area. Surgery was performed; histologic examination disclosed the lesion to be renal cell carcinoma.

Photoscanning has been helpful in evaluating non-functioning kidneys on the basis of excretory urograms. Of 13 patients in this group, 6 had one kidney as confirmed by a battery of diagnostic studies. In 3 cases, the scan did not show radioisotope uptake in kidneys known to be present. In 4 cases, however, the scan depicted renal tissue which had no visible function on excretory urograms and also provided good structural information in a case with a blood urea nitrogen of 40 mg%. Renograms on these patients also failed to indicate function on the involved side.

Table 4.

Cases of Non-Functioning Kidney Detected by Excretory Urograms

	Cases
No function - on scan	9
Absent kidney	6
Kidney present (false negative)	3
Function detected - on scan	4
Total	13

Case 4. A 20-year old Caucasian male was referred to this hospital for admission because of hypertension. An excretory urogram was performed and showed no detectable renal function on the right side; there was compensatory hypertrophy on the left. The photoscan depicted a large symmetrical left kidney, also some uptake by the liver. There was a small area of activity apart from the liver in the right renal region; this was interpreted as functioning renal tissue. The retrograde pyelogram showed an atrophic right kidney.

(To be continued)

* Dr. Brooks is now staff member of Urology Service, USNH Portsmouth, Va.

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MISCELLANY

A New Heart-Lung Machine *

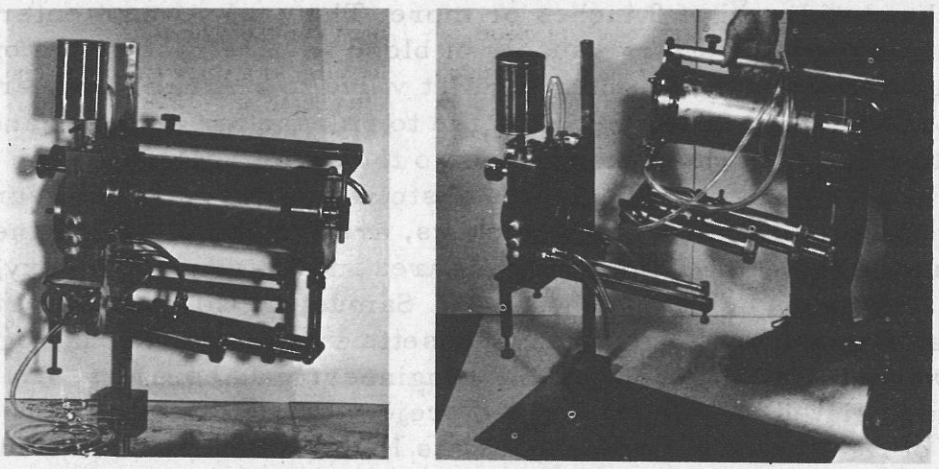
From: Naval Research Reviews, Office of Naval Research XVI(10): 15-16, October 1963.

The development of a simple cheap and easily operated pump-oxygenator or heart-lung machine has been completed for the Navy by the Massachusetts Institute of Technology under contract with the Office of Naval Research. The machine—which must undergo clinical testing before it can go into general use—weighs only 50 pounds and takes up 1.5 cubic feet of space. This makes it particularly adaptable for use aboard naval ships and at small field hospitals.

Among the chief advantages of the new machine is that it can be operated easily by one person, and that it needs only one liter of blood for priming as compared to three to four liters for current machines. Its low cost, about $1000, would make it available to many hospitals which cannot afford the expensive machines now in use.

The pump-oxygenator is highly reliable and does not require electricity for its operation, thereby removing the danger which arises during operation of present machines if the power fails. The entire machine can be sterilized in its assembled state immediately after an operation and then held ready for instant use, eliminating the time necessary to prepare current machines for use, which can be critical in an emergency operation. Another feature of the simple design is that it can be quickly adjusted for use either on an infant or an adult merely by varying the oxygen rate.

One purpose of the research program which led to this development was to design a heart-lung machine that would prolong the period of safe bypass of the heart and lungs. Moreover, present machines are not entirely satisfactory for myocardial infarcts (heart blocks), severe shock, massive pneumonia, congestive heart failure, and pulmonary edema.



The pump-oxygenator. Left, the unit is assembled and ready for use. Right, a technician holds the small, portable sterilized unit.

The machine's oxygen-driven engine is mounted on a platform supported by a post rising from an aluminum base. When the machine is to be used, the completely assembled sterile package is unwrapped and attached to the engine block by merely adjusting two screws. Three short plastic tubes are then slipped into place. They supply oxygen pressure to the pumps and to the surge chamber.

A stationary glass cylinder houses a slightly smaller rotatable stainless steel cylinder. Inside the latter is a nest of open-ended stainless steel cylinders and then a closed-end cylinder. When the outermost stainless steel cylinder rotates, the other cylinders roll on each other in an attempt to remain in the lowest possible position in response to gravity. Thus, although the blood level may be low, all surfaces become filmed with blood.

Blood from the oxygenator flows through a metal valve into a blood pump, inside which is a silicone rubber tube 1-1/8 inch in diameter and 8 inches long. Oxygen under pressure enters the space between the tube and its metal housing. Blood is expelled through a valve at the other end of the

tube. A surge chamber, similar to the tube except that it has no valves, softens the blood's pulsations. A gauge on the engine block shows the rise and fall in pressure in the surge chamber.

After the machine has been used, everything that came in contact with the blood (oxygenator, pumps, surge chamber, and piping) is cleaned and completely reassembled. The equipment is wrapped, sterilized, and remains in that condition until needed. When the machine is again needed, it is charged with sterile saline, then with blood. A special float valve brings the system to an even keel. Venous blood enters the oxygenator by gravity. Inside the stationary cylinder, rotation causes the other cylinders to dip into this pool of blood where they are filmed. Oxygenation can be increased by increasing the number of cylinders or the rate of rotation.

The blood goes from the oxygenator down through a U-tube and up through the pump's inlet valve. This gravity-controlled valve can be opened only by a head of liquid of 8 inches or more. Thus, air cannot enter the pump so there is no need for a large supply of blood to be stored in the oxygenator. The blood flows through the pump's outlet valve to a surge chamber. This compartment has a filter, an outlet at the top to release air bubbles, and an outlet at the bottom through which blood flows to the patient. During each cycle of the pump, a pressure gauge registers systolic and diastolic pressures. Two small air pumps, called coronary suckers, are located in the engine block and siphon leakage blood from the operating area and deliver it to the oxygenator.

In charge of the research was Dr. Samuel C. Collins, Department of Mechanical Engineering of the Massachusetts Institute of Technology. The machine was built at MIT's Cryogenic Engineering Laboratory. Dr. Ernest M. Barsamian assisted Dr. Collins on the project. In addition to ONR, National Institutes of Health and the Massachusetts Heart Association provided support for the research. Laboratory and clinical tests were conducted at Sears Surgical Laboratories and the Harvard Surgical Service at Boston City Hospital. A byproduct of this research program was development of a new infusion pump for use in chemotherapy. This pump is already being produced and used.

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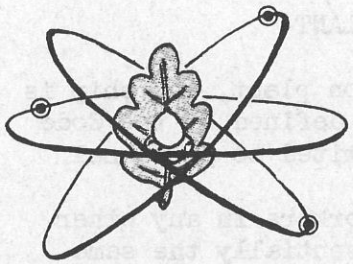
Topical Ophthalmic Anesthetic Preparations. The attention of Medical Department personnel is invited to the hazard of indiscriminate use of topical ophthalmic anesthetic preparations. Topical ophthalmic anesthetic agents have been reported to diminish the metabolism of the corneal epithelium. Because of this, indiscriminate repeated application of topical ophthalmic anesthetics may be a factor in unnecessary corneal pathology. Therefore, use of topical ophthalmic anesthetic agents should be confined to immediate relief of pain and to facilitate immediate ocular examination, diagnosis, and treatment. It must be emphasized that relief of continuing ocular pain should be by systemic medication and not by topical anesthetics. Only under battle conditions is it considered necessary occasionally to dispense topical ophthalmic anesthetic agents to patients for self-application. —Surgery Branch, ProfDiv, BuMed.



RADIATION MEDICINE

RADIATION MEDICINE

RADIATION CONTROL ABOARD THE USS ENTERPRISE CVA(N)65

By - LCDR Lewis H. Seaton, MC, USN*

THE USS ENTERPRISE CVA(N)65, the largest ship in the world, requires 8 nuclear reactors to propel its 86,000 tons at speeds "in excess of 40 mph." The health of the 4600 personnel aboard is safeguarded by strict adherence to regulations and procedures and latest control practices for handling radioactive materials.

REACTOR CONTROL PROGRAM

In addition to the nuclear reactors, a modern naval ship such as the ENTER-PRISE may carry a diverse array of radiation sources, including medical and dental X-ray equipment, radioactive electronic tubes, amplifier tubes for radar equipment, nuclear weapons and calibration sources for monitoring instruments.

To insure that personnel are not exposed unnecessarily to radiation sources, all hands are required to be familiar with a ship's instruction which sets forth the basic tenets of the radiation control program. This instruction incorporates the BUSHIPS, AEC, and other government agencies' rules and regulations pertaining to radiation control which are specifically applicable to the ENTERPRISE. The radiation control program is coordinated and administered by the Radiation Control Officer.

RADIATION CONTROL OFFICER and DAMAGE CONTROL OFFICER

While he normally functions through department heads, the nuclear-trained Radiation Control Officer is directly responsible to the Commanding Officer for all areas of radiation control. Because of his intimate specific knowledge of the subject, the Radiation Control Officer makes independent inspections to reveal any careless or inadvertent infractions of the regulations and instructions, or errors in reading, reporting and controlling radiation instruments, sources and other radioactive materials. He makes use of graphs, check off lists, tickler files, and automatic reminders to insure that instructions and procedures are performed accurately and on time as required.

The Damage Control Officer is charged with the responsibility for handling the gross levels of contamination expected in nuclear warfare. However, the Radiation Control Officer advises, assists and trains the monitoring and decontamination teams which are needed in the event of high level contamination. The members of monitoring and decontamination teams are selected from damage control personnel to receive this supplemental training to handle large scale contamination, since the small number of personnel routinely required for radiation control operations would be inadequate.

*At time article was written LCDR Seaton was attached to the USS ENTERPRISE. Abstract from article in Arch. of Environ. Health, VII, 3, Sept. 63, 320-324.

RADIATION CONTROL IN THE PROPULSION PLANT

For purposes of radiation control in the nuclear propulsion plant, the ship is divided into a "restricted" and an "Unrestricted" area as defined by the Code of Federal Regulations. Access to restricted areas is limited to personnel wearing specific identifying film badges.

Personnel in this group are handled and trained as workers in any other industrial atomic power plant and they are governed by essentially the same rules. Personnel working outside the nuclear plant are treated as the general public residing in an "unrestricted" area. This approach does not restrict routine ship's operations.

The Reactor Department and the Medical Department each maintain a survey group for radiation control purposes. They periodically perform surveys in their respective zones of responsibility. The frequency of monitoring surveys varies—daily or more often in continuously manned areas, weekly in less accessible plant areas, and monthly in areas occupied only on occasion. The Reactor Laboratory Division of the Reactor Department performs chemical analyses on the nuclear plant, and radiation surveys within the plant area comparable to the industrial organization in most nuclear industries. The Health Physics Section of the Medical Department surveys the ship outside the propulsion plant somewhat like a public health organization in a civilian community. This Section also performs all personnel dosimetry functions.

Decontamination stations for each propulsion plant are provided with facilities to issue clean anticontamination (Anti-C) clothing and receive contaminated clothing. Although the plant's routine operation does not require special clothing, Anti-C clothing is used during maintenance operations to protect personnel from loose radioactive material. A special laundry is maintained in one plant for washing contaminated clothing.

PERSONNEL DOSIMETRY

Individual film badges are used for routine monitoring on ENTERPRISE. These badges contain three films—a neutron track film, a high range and a low range β-γ film—which are processed and read monthly. Guests and occasional visitors receive a film badge for use only while in the confines of the plant. No one has approximated the maximum permissible limits of radiation exposure. To date the man having the highest radiation exposure is the dental technician who takes dental X-rays.

Nuclear plant personnel use exposure limits listed in the Code of Federal Regulations for workers in nuclear industries: (1) 3 rem per quarter, and (2) a maximum accumulated lifetime dose not to exceed 5 rem per year over the age of 18. For personnel outside the propulsion plant, exposure limits are one-tenth of the above limits.

RADIOACTIVE MATERIAL ACCOUNTABILITY

Strict accountability of all radioactive material aboard ENTERPRISE is one of the most important aspects of radiation control. All materials taken out of a reactor space or system are monitored as they are removed. If found radioactive they are accounted for at all times until they leave ship on their way to an authorized facility. Special cards are used when ordering materials labeled "Radioactive." A qualified monitor inspects all such material received on board ship to establish presence and condition of radioactive material before receipt is signed. Receipt and expenditure logs are maintained. Dry radioactive wastes are disposed of by transfer to authorized shore handling facilities.

Low-level liquid reactor plant wastes, after being analyzed for radioactive content, are discharged overboard in accordance with AEC approved procedures. The Health Physics technician monitors the transfer of all radioactive material through unrestricted ship areas.

TRAINING

Officer selection for training in the nuclear power program is contingent upon final personal interview by VADM. Rickover and his staff. A basic 6 months' academic nuclear training at either New London, Conn., or Mare Island, Calif., is followed by approximately 6 months' practical experience at a reactor prototype. All personnel receive general training in radiation control practice. Those who will be working in this field exclusively receive specialized training in radiation control. All installations have similar types of qualification cards to standardize and document training received. Candidates are examined by a board of qualified operators before certification for a nuclear designation. Emergency drills and practice continue after the operator reports for duty aboard a nuclear powered ship.

MEDICAL FUNCTIONS

Each man ordered to duty in the nuclear propulsion plant receives a preemployment physical prior to assignment. This examination includes a slit lamp examination and a determination of the baseline of circulating white blood cells. The Medical Department trains for and is equipped for the treatment of casualties contaminated with radioactive material. Using basic procedures for the safehandling of radioactive material, the patient is decontaminated before entering the sickbay, if possible. However, lifesaving procedures always come first.

EXPERIENCES WITH FALLOUT

The 1961 Soviet atmospheric nuclear tests caused problems. Rainstorms washed fallout from the sky contaminating external ship's areas on the order of 10 to 20 times that allowable for the nuclear plant area. Concerted efforts were made to prevent the fallout from entering the ship thru the ventilation system or on feet of workmen. Machinery spaces, filter plenum rooms and galleys, having direct ventilation, were hardest hit. Cheesecloth over the ducts helped; but the condition persisted for about a month. As the radiation limits inside the ship were exceeded, the contaminated area was cleaned up. There was no real danger to health, as levels of contamination were still within tolerable levels, averaged over a period of time. In January 1962 fallout again became noticeable but from a different cause. The jet aircraft assigned ENTERPRISE flew at such altitudes that the engines, leading edges of wings, and control surfaces became contaminated with fallout still lingering in the heights. It was necessary to survey the aircraft for contamination prior to commencement of maintenance work on them. Fallout levels subsequently decreased to the point where they are no longer a problem.

SUMMARY

The radiation control program aboard ENTERPRISE is based principally on three factors: (1) the adequate training of all personnel in good radiation control practices; (2) careful application of time-proved procedures and strict adherence to the regulations concerning radioactive materials; (3) design and establishment of the billet of Radiation Control Officer with the responsibility of coordinating and controlling all phases of the radiation control program.

DENTAL SECTION

Test to Demonstrate Glucose in Saliva

Gerald J. Cox, Frank J. Draus, and Cheryl P. Entress, School of Dentistry, University of Pittsburgh. How Long Does Sugar Remain in the Mouth? Dental Progress 3: 152-154, April, 1963. From Dental Abstracts 8(10): 618, October 1963.

A test has been devised which can be duplicated in any home, classroom, or dental office to impress on patients the reasons behind toothbrushing.

The materials used in the test are paper strips of Tes-Tape (Eli Lilly & Co.) for demonstrating the presence of glucose in saliva; commercial corn syrup mixed with tap water in a 1:5 dilution; a clock; small paper cups, and flat birch toothpicks. Each subject is given a sheet of white paper to which are attached strips of Tes-Tape, measuring 1/4 by 4 inches. The strips are numbered in increments of 3 from 0 to 27 minutes for recording at 3 minute intervals. He is then given a small paper cup into which he pours 12 ml of glucose syrup solution which had been prepared in his presence. Also he receives a supply of toothpicks and is instructed not to touch the Tes-Tape with his fingers.

The subject touches the saliva in his freshly rinsed mouth with a clean toothpick and places a dot of this saliva on the Tes-Tape strip labeled "zero." He dips a clean toothpick into his cup of glucose and places a dot of this on the strip of Tes-Tape labeled "solution"; the second dot quickly turns green. He then rinses the glucose solution in his mouth for 30 seconds, swallows it or spits it out, and immediately takes a sample of his saliva with a clean toothpick. This dot of saliva is placed on the Tes-Tape beside the other at the zero time mark. Thereafter, at intervals of 3 minutes, each subject samples his saliva with a clean toothpick and places the saliva dot on the Tes-Tape strip next to the proper time indication. The yellow test paper turns green under the dots of saliva until the glucose solution has been cleared from the mouth by salivation.

Placing saliva on the Tes-Tape at spaced intervals indicates how long it takes to clear glucose from the mouth. Since glucose facilitates bacterial growth and ferments rapidly—producing an acid strong enough to decalcify enamel—this demonstration emphasizes the importance of a thorough brushing and/or rinsing after meals. Those individuals with longer clearance times should exercise particularly rigid oral hygiene.

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Method of Instruction in Oral Hygiene

J. D. Manson and J. O. Forrest, London, England. Brit Dent J 114: 163-165, March 5, 1963. From Dental Abstracts 8(10): 593-594, October 1963.

The authors present a technic for instruction in oral hygiene that is simple and generally applicable. This service, contributing to the improvement of oral health, is considered to be the most important single service a dentist can render his patient.

The subject of oral hygiene is introduced at the first meeting with the patient. With the aid of a disclosing solution (four drops of 6% basic fuchsin in a tablespoon of water followed by a rinse with plain water to eliminate the excess) the plaque can be demonstrated to the patient by using a hand-held face mirror.

The patient is then asked to brush his teeth. By close observation, the dentist corrects the patient's method of brushing. In this manner, the patient realizes his faults and is ready to learn the correct method. In addition to the technic of brushing, the importance of diet and brushing after eating are stressed. To be most effective, teaching of oral hygiene must be individual. Class instruction, although valuable, merely serves to give a broad outline and never is matched to the patient's individual requirements. There is no substitute for chairside instruction.

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Types of Dental Amalgam and Variations in Manipulation

Langeland, Kaare. Institute for Dental Research, Oslo, Norway. Norske Tannlaegeforen 73: 1-17, January 1963. From Dental Abstracts 8(8): 498-499, August 1963.

Alloys used in this study complied with the ADA Specification No. 1 for Dental Amalgam Alloy, provided they were treated strictly according to the manufacturer's directions and manipulative deviations were within the borders of good practice.

The variables in manipulation included: mixing the alloy with a too low mercury ratio, over trituration and expressing mercury during initial mulling. The results indicated that alloys should always be manipulated in accordance with the manufacturer's instructions. A low ratio of mercury results in shrinkage and the formation of spaces between the tooth substance and the amalgam.

Periodontal Pathosis in Man: IV. Effect of Protein Vs. Placebo Supplementation on Gingivitis

W. M. Ringsdorf, Jr, D M D M S and E. Cheraskin M D D M D, Department of Oral Medicine, University Medical Center, Birmingham, Ala.
Journal of Dental Medicine 18(2): 92-94, April 1963.

This report presents findings of a study of the effect upon gingivitis of a known quantity of protein supplement versus a placebo. A group of 44 junior dental students participated in the study. The degree of gingivitis, graded on a four-point system, was determined. On a random basis, one-half were given a forty gram per day protein supplement; the other half received forty grams daily of an indistinguishable placebo. The mean gingivitis score was determined four days later by the same examiner, with no knowledge of the previous gingival values or the type of supplementation. The results indicate a significant reduction in gingivitis only in the protein-treated group.

Comment. If a significant reduction in gingivitis is possible as reported in this study, it seems logical that a protein supplement would contribute toward prevention of gingivitis. Therefore, in diet discussions with patients, it is recommended that the protein portion of the diet be stressed with this prevention factor in mind, as well as the healing potential.

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Personnel and Professional Notes

Congratulation to Dental CPO's. BUPERS NOTICE 1430 of 1 November 1963 announced the advancements to Senior Chief Petty Officer and Master Chief Petty Officer on 16 November 1963. The selection board, convened to consider the candidates, had the difficult assignment of determining those most qualified by reviewing their records. Congratulations to the individuals selected for exceptionally fine records. To those not selected, also a "Well Done" for their outstanding records. Those with continued outstanding performance will have additional reports working for them when future boards are convened.

To DTCM

Richard Lindstrom Thomas Lonergan James T. O'Brien

To DTCS

R. S. Anson	R. M. McCabe	D. A. Shear
R. W. Cabana	J. McCusker	L. Sitterson
D. A. Cash	R. L. Mohr	J. Thompson
E. Corder	R. R. Robinson	W. L. Willis

Project HOPE in Need of a Dentist. The officials of project HOPE have corresponded with the American Dental Association in an attempt to find a dentist for their mission. The dentist would serve a ten month assignment beginning January 1, 1964, on board the ship HOPE. The position will pay $500 a month in addition to transportation, room and board. Members of the Navy Dental Corps who are being released from active duty at about this time and are interested in applying for this position, may write the Washington office of project HOPE, 1016 Twentieth Street, N. W., Washington, D. C.

Navy Dental Corps to Participate in Disaster Recovery Study. CAPT V. J. Niiranen DC USN, Staff Dental Officer, Headquarters, U. S. Marine Corps has accepted an invitation to serve as a member of a study committee that will have as its goal the redefinition of the role of the dentist during a period of recovery from disaster. This committee will be composed of knowledgeable leaders in the dental profession and is being established as a joint effort between the American Dental Association and the U. S. Public Health Service. The conclusions and recommendations developed by this proposed committee will be advisory only, and will not represent the official policy of the A. D. A. unless they are subsequently approved by the House of Delegates.

U. S. Navy Dental Corps Continuing Training Program. The U. S. Naval Dental School, Bethesda, Md., is continuing the series of short postgraduate courses for Fiscal Year 1964 with the course "Occlusion" to be presented 24-28 February 1964. The instructor will be CAPT G. H. Rovelstad.

This course is designed to present, by lectures and demonstrations, the concepts of occlusion. Subjects to be discussed are the anatomy and functions of the components of the masticatory system, the effects and treatment of occlusal harmonies and disharmonies, and methods of determining normal and abnormal jaw and tooth relationships.

Quotas for the course have been assigned to ComOne, ComThree, ComFour, ComFive, ComSix, ComNine, PRNC, CNATRA, and SRNC. When districts who have quotas assigned do not fill the quota 4 weeks prior to the commencement of the course, the quota may be assigned to personnel from other areas who may have applied.

Applications should be received in the Bureau as early as possible and preferably, not less than 4 weeks prior to commencement of the course. The Bureau Professional Advisory Board will make recommendations on all requests, and upon approval by the Surgeon General, applicants will be notified as to the final action. Those approved will be nominated for TAD or authorization orders, as appropriate. Accounting data will be forwarded to individual officers nominated for TAD orders. Staff Dental Officers not utilizing assigned quotas should report this information to BUMED, Code 6111, one month prior to the convening date of the course. This will allow the Bureau to fill the quota from other districts.

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RESERVE SECTION

Reserve Inactive Medical Officers Certified by American Board of Internal Medicine

LCDR Ronald A. Arky MC USNR	606291
LT Nicholas J. Cifarelli MC USNR	611470
LT Eugene P. Clerkin MC USNR	614297
LT John L. Conboy MC USNR	593442
LCDR George E. Ehrlich MC USNR	582649
LT Matthew J. Ferguson MC USNR	603393
LT Arthur F. Goldberg MC USNR	611852
LCDR Eugene L. Gottfried MC USNR	585719
LCDR James W. Hanway MC USNR	571024
LT Edwin A. Henck MC USNR	238577
LCDR Richard A. Herrmann MC USNR	606197
LCDR Lansing C. Hoskins MC USNR	589107
LT Frederick A. Klipstein MC USNR	582557
LT Norman Krasnow MC USNR	601797
LCDR Thornton W. Merriam Jr. MC USNR	609048
LCDR James P. Nolan MC USNR	608360
LT Robert K. Osborne MC USNR	615560
LT Robert H. Resnick MC USNR	605444
LCDR George L. Rivara MC USNR	616476
CDR Sidney W. Rosen MC USNR	469593
LT Leonard R. Schaer MC USNR	618887
LT Paul Schlein MC USNR	613053
LCDR Sheldon A. Sorokoff MC USNR	606692
LCDR William Steier MC USNR	617232
LT Michael A. Sullivan MC USNR	569774
LCDR Frank J. Takacs MC USNR	618121

This information has been posted to reflect additional professional qualification.

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AVIATION MEDICINE DIVISION

Visual Impairment From Exposure* To High Intensity Light Sources

This article describes research conducted to determine the visual incapacitation which results from exposure to high intensity light sources. Direct viewing of a sufficiently intense source can result in permanent retinal damage. Less intense light may produce "flash blindness," a temporary but reversible loss of vision which does not involve permanent damage.

It is only within about the last ten years that substantial scientific interrest has been shown in the effects of high intensity light on vision. At the present time, man is capable of sustained operation within a space environment. Here, without the diffusion of light by the atmosphere, he may transition rapidly from extreme darkness to very bright light. This change could cause serious loss of visual efficiency. A second concern, particularly for the military, is over the effects of the extremely intense visible radiation released during a nuclear detonation. During combat conditions, an aviator operating within a nuclear environment might be exposed to the light from a number of bursts. Since for the most part these bursts would be from weapons other than his own, he would not be prepared for them and would not know in advance to shield his eyes. Consequently, he might suffer a period of impairment lasting for many seconds. On certain missions, a loss of vision for only a few seconds could cause complete failure.

Within the space and the nuclear combat environments, flash blindness, rather than permanent retinal burns, appears to be the primary problem. It is doubtful that an astronaut will look directly at the sun for a long enough period to produce permanent damage. It is also improbable that an aviator will be looking directly at an unexpected nuclear burst. It is only through such direct viewing that he might suffer retinal burns. It is quite likely, however, that in either environment an individual will be exposed to enough light to produce some period of flash blindness. For this reason, the bulk of this article is concerned with the problem of flash blindness rather than with that of permanent retinal damage.

The Army, Navy, and Air Force have supported a number of programs in recent years designed to develop devices and procedures to protect a person from flash blindness. Certain of these efforts have been concerned with passive protective devices such as monocular eye patches and low transmittance goggles.

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* BioTechnology, Inc. Report No. 63-2. Office of Naval Research contract for DASA and BuWeps.

Others have investigated more elaborate active protective systems which operate only when exposed to high intensity light. These include goggles which become opaque either through the activation of explosive components or through a basic change within the chemistry or physical characteristics of the lens itself. At this time, however, no device has been developed which is totally satisfactory for all military situations.

A separate part of programs recently sponsored by the military has been directed towards specifying, with precision, the extent of the flash blindness hazard in nuclear combat situations. While the hazard obviously is there, until this time it has been stated only in terms more qualitative than quantitative. There is no comprehensive model which will indicate the extent of the flash blindness hazard as a function of such parameters as altitude of burst, altitude of observer, distance from burst, viewing angle, and meteorological conditions. The development of appropriate protective devices will be aided by the preparation of such a model.

HIGH INTENSITY VISIBLE RADIATION

It is important to understand the nature of the physical stimuli which are likely to produce visual impairment. As indicated, these consist of nuclear explosions and solar radiation. In the case of nuclear radiation, however, much information concerning the exact spectral distribution during the time history of a burst is still to be obtained. There is a better understanding of solar radiation as it exists both in and out of the atmosphere of the earth.

Nuclear Radiation Effects

Published information concerning the spectral emittance characteristics during the time history of a bomb burst deals mostly with low yield weapons. Byrnes et al (1955) state that a 20 KT weapon produces a fireball approximately 90 feet in diameter, 0.1 milliseconds after detonation. This expands to ten times this size during the first second and retains this size during the first three seconds. During this time the fireball is cooling rapidly. The surface temperature at 0.1 millisecond is 300,000° K. After 10 milliseconds, it has cooled to 2,000° K. There is then a rise in surface temperature which reaches a maximum of 7500° K early in the first second. After 3 seconds the fireball drops to ambient temperature. During this time the radiant flux per unit area and the quality of radiation change considerably as the surface temperature of the fireball changes.

Figure 1 presents the spectral emission curves of black bodies 2,000°K, 300,000°K, and 6,100°K, approximating the three phases of the atomic fireball described above. These curves provide a fairly accurate picture of the spectral emittance characteristics during the bomb burst. Note that at 0.1 millisecond, while the surface temperature is quite high, maximum radiation occurs in the ultraviolet and visible portion of the spectrum. At 10 milliseconds, primary radiation is in the red and infrared bands. During the latter part of the burst

history, radiation is distributed fairly evenly from the ultraviolet band through the entire visible spectrum and into the infrared band.

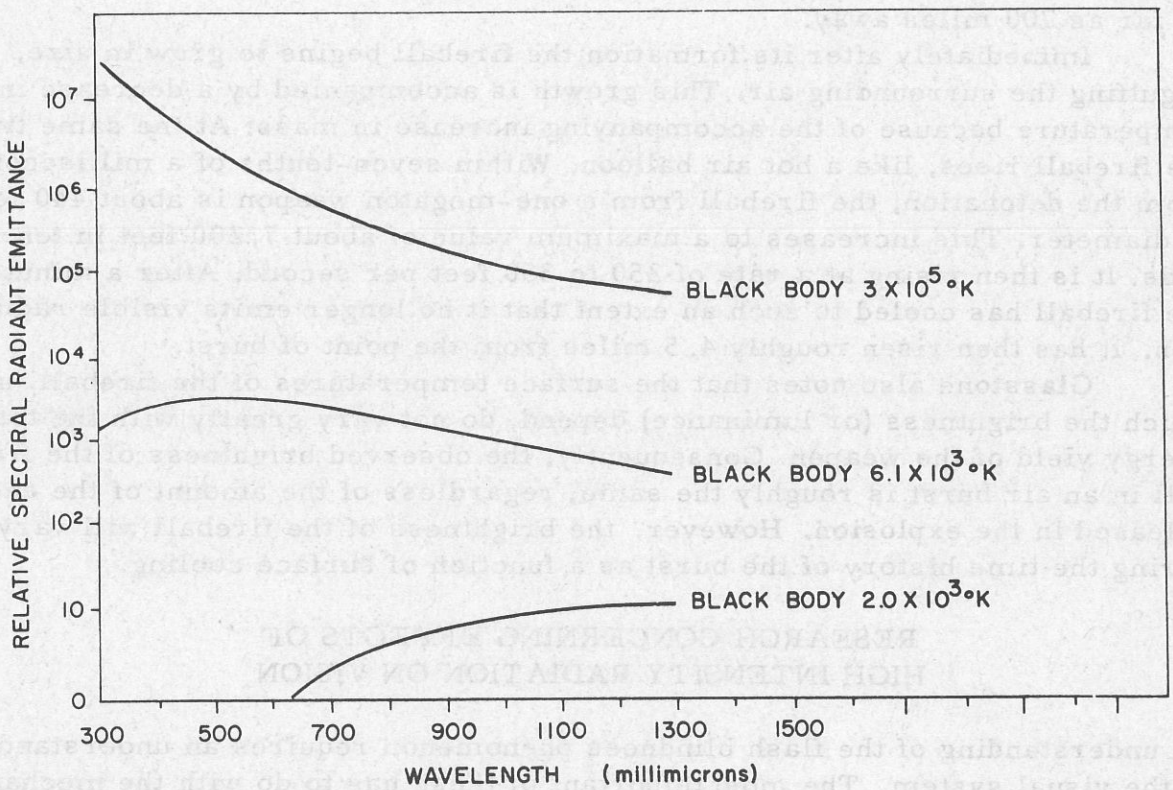

Fig. 1. Spectral emission curves of black bodies 300,000° K, 6100° K, and 2000° K. (Byrnes et al, 1955)

The above discussion was concerned with a weapon of 20 KT yield. For larger weapons there will be an increase in the relative amount of energy at shorter wave lengths. For either class of weapon, however, most of the radiant energy will fall between 300 and 2400 millimicrons, with the greatest part occurring at less than 1400 millimicrons (Brown, 1961).

Glasstone (1962) describes certain characteristics of the visible radiation from a burst with a yield of one-megaton TNT equivalent. He indicates the maximum attained temperature for this type of weapon will be several tens of million degrees. Because of the great heat produced by the nuclear explosion, all materials are converted into gaseous form. Within less than a millionth of a second of the detonation of the weapon, the extremely hot weapon residues radiate large amounts of energy, mainly as invisible X-rays, which are absorbed within a few feet of the surrounding atmosphere. This leads to the formation of a hot, and highly luminous, spherical mass of air and gaseous weapon residues referred to as the weapon fireball. The surface brightness of this fireball decreases with time, but after about a millisecond the fireball from a one-megaton

nuclear weapon would appear to an observer fifty miles away to be many times more brilliant than the sun at noon. The intensity of the light is indicated by the fact that high altitude bursts in the megaton range have been seen directly as far as 700 miles away.

Immediately after its formation the fireball begins to grow in size, engulfing the surrounding air. This growth is accompanied by a decrease in temperature because of the accompanying increase in mass. At the same time, the fireball rises, like a hot air balloon. Within seven-tenths of a millisecond from the detonation, the fireball from a one-megaton weapon is about 440 feet in diameter. This increases to a maximum value of about 7,200 feet in ten seconds. It is then rising at a rate of 250 to 350 feet per second. After a minute, the fireball has cooled to such an extent that it no longer emits visible radiation. It has then risen roughly 4.5 miles from the point of burst.

Glasstone also notes that the surface temperatures of the fireball, upon which the brightness (or luminance) depend, do not vary greatly with the total energy yield of the weapon. Consequently, the observed brightness of the fireball in an air burst is roughly the same, regardless of the amount of the energy released in the explosion. However, the brightness of the fireball will vary during the time history of the burst as a function of surface cooling.

RESEARCH CONCERNING EFFECTS OF HIGH INTENSITY RADIATION ON VISION

An understanding of the flash blindness phenomenon requires an understanding of the visual system. The most important of these has to do with the mechanism by which the eye adjusts the amount of light which enters. The iris controls this amount of entering light. It is a delicate membrane stretching across the interior of the eye at the base of the corneal bulge, with a circular opening (the pupil) near the center (Wulfeck et al, 1958). The pupil dilates to admit more light and contracts to admit less. The pupil normally varies in diameter from approximately 2 to 8 mm, a ratio of pupillary areas of 1 to 16. However, the ratio of the weakest light the eye can see to the strongest it will tolerate is on the order of 1 to 10 billion. The ratio of pupillary area to eye exposure thus is extremely nonlinear.

A certain time is required for the eye to adjust itself to different input levels of illumination. When the eye is exposed to a sudden increase in illumination which is still within the normal range, there is a brief interval of partial blindness. However, depending upon the extent of the over-stimulation, it usually is possible to see quite effectively again within a short period. The change from a low to high adaptation level customarily occurs in less than a minute. However, the converse is not true. When the illumination is reduced from a high to a very low value, 30 or more minutes may be required for the achievement of maximum sensitivity.

The primary photochemical substances of the eye are located in the retina. The retina itself is separated into two regions. The fovea subtends only about 3 degrees of visual angle and is the area of acute daylight (photopic)

vision. The surrounding broad area is the peripheral retina which contains elements sensitive to very low light intensities. This is the area which is used in night (scotopic) vision.

Permanent Injuries to the Visual System

Chorioretinal burns represent a pathological condition in which there is irreversible tissue damage and some permanent loss of vision. The condition is caused by the absorption of excessive amounts of thermal energy in the retina and in the underlying layers, principally the choroid. Susceptibility to this type of damage is traceable directly to one of the fundamental eye processes—that of optical focusing and image formation. As a result of the interrelationship of optics and geometry, the thermal loads on the retina of the eye, and hence the probability of incurring retinal burn, remain quite high at relatively large distances from a nuclear explosion, distances at which most other effects are negligible.

In their long term effect, seriousness of retinal burns depends upon such factors as tissue involvement (size and depth of lesion) and on location in the visual field. Large burns may invite grave aftereffects such as retinal detachment; small burns are not likely to cause serious visual impairment unless they occur on the region of the retina associated with acute vision (macula) or perhaps on the blind spot (optic disc). However, of greater concern in tactical planning are the possible immediate effects of retinal burning. Descriptions of post-exposure effects are meager, viz., that immediate vision loss occurs equivalent to severe flash blindness and, on recovery of adaptation, there is possible persistence of discomfort.

Ham (1962) has conducted recent experiments, using rabbits to produce the minimal thermal energy which will produce chorioretinal lesions. He used Zeiss Light Coagulator capable of producing a maximum irradiance on the rabbit fundus of approximately 1100 $cal/cm^2/sec$. An exposure time of 175 microseconds resulted in a total dose of 0.2 cal/cm^2. This energy level produced lesions barely visible by ophthalmoscopic observation which appeared in 3 to 5 minutes following exposure. Under the same conditions, but with the total energy dropped to 0.16 cal/cm^2, no lesions were observed. This energy level appears to represent threshold dose for visible lesions. This threshold dose appears to represent the lowest value determined experimentally to date. It is important to note that this dose value is for energy at the retina and not at the corneal plane.

Flash Blindness

The term flash blindness refers to the effects of exposure to sudden and intense light which renders the eye temporarily useless. From the point of view of a military pilot, this is the important problem area. It is doubtful that he will experience permanent visual damage unless he is quite close to the burst point or is looking directly at the fireball. However, a burst anywhere within several hundred miles might provide sufficient visible energy to produce flash blindness.

Experimental Investigations of Flash Blindness

Empirical evidence is available as to the effect upon vision of exposure to sudden and very intense light. Several important investigations are described. The results of these studies show certain very definite trends but are not entirely consistent. The inconsistencies which exist may be due to differences in experimental techniques or, as seems more likely when considering the limited number of subjects in each study, to differences in the characteristics of the visual mechanisms of different individuals. It is known that people vary with respect to dark adaptation time, visual acuity, susceptibility to visual illusions, and any number of other visual performances. It seems likely, then, that individual differences exist concerning susceptibility to flash blindness.

Metcalf and Horn (1958) conducted experiments designed to specify visual recovery time from high intensity flashes of light. A carbon arc was used as a light source to determine the course of visual recovery after exposure to a level of illumination comparable to that likely to be encountered during nuclear operations. Each of the four subjects' pupil was dilated prior to exposure. A 6 mm artificial pupil was used in order to maintain constant pupil size. The subjects were exposed for 0.1 second to illumination ranging from 60 to over 12,000 lumens per square foot. Following exposure, subjects were required to detect the flashing of a 17 minute visual angle circular patch. The primary conclusion of the authors is that exposure to intense light, similar in nature to that which might be encountered in the vicinity of a nuclear detonation, will require a maximum of approximately 170 seconds for recovery to read red-lighted instruments.

The time required to recover visual sensitivity following exposure to high intensity, short duration adapting flashes also has been investigated by Chisum and Hill (1961). In contrast to other investigations, this study used extremely short exposure flashes. Adapting flashes of 33 to 165 microseconds and 9.8 milliseconds in duration with luminances from 4.1 to 8.6 log mL were used. Visual sensitivity was determined by the resolution of gratings requiring acuities of 0.13 and 0.33 at display luminances from -2.50 to 2.25 log mL. The 0.33 acuity level requires the function of cones while the 0.13 acuity level can be resolved by rod vision. The authors found that for a given adapting flash luminance recovery time is a decreasing negatively accelerated function of display luminance. That is, recovery time decreases with an increase in display luminance but at a decreasing rate. Figure 2 illustrates this. It was also found that recovery time decreases with a decrease in the intensity of the adapting flash and with a decrease in the visual acuity requirement of the display. Of these variables, the visual acuity requirement of the display appears to influence recovery time the least. It was found that when the display luminance exceeded 0.5 log mL, recovery at the higher visual acuity requirements was about as rapid as that at the lower visual acuity requirement. The authors conclude that the significance of visual acuity as a factor in the flash blindness problem may be reduced by having display luminance above this value.

Chisum and Hill also investigated the relationship between the total energy of the adapting flash and recovery time. It was found that as the total

energy in the flash is increased, recovery time at first increases very slowly, then rapidly, and then apparently slowly again. They suggest that the possibility exists that after integrated luminance has reached a level of more than 6 log (mL-sec), no further increase in recovery time will occur, provided irreversible eye damage is not inflicted.

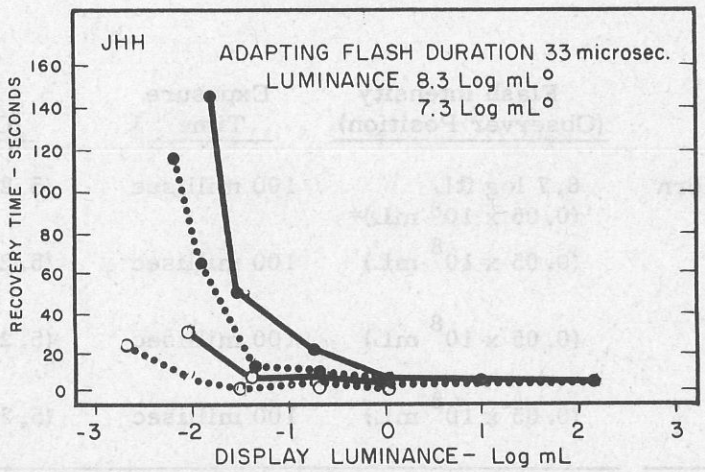

Fig.2. Effect of increasing display luminance on time to perceive an acuity target following exposure to an adapting flash. (Chisum & Hill, 1961)

Particularly interesting is the finding of Chisum and Hill that, when the total energy received at the eye remains constant, a decrease in exposure time will reduce the ensuing period of flash blindness. This is not a one-to-one relationship, however. A comparison of two exposure times, 9.8 milliseconds and 165 microseconds, indicates that a sixty-fold decrease in exposure time reduces recovery time by about one-half.

Whiteside (1960) performed an experiment to measure the brightness of an actual nuclear explosion and the amount of flash blindness associated with it. In this experiment, the subject's head was positioned so that the image of the fireball would be formed three degrees on the lateral side of the fovea. The explosion distance was approximately 30 miles. Following exposure, the subject viewed an adaptometer containing test fields at three luminance levels (1.04, 0.41, and 0.14 foot-lamberts). The time was noted at which each test field could be initially discerned through foveal vision and through the afterimage of the fireball. The following recovery times were noted:

Adaptometer luminance	1.04 ft-L	0.41 ft-L	0.14 ft-L
Through fovea	5 sec	17 sec	58 sec
Through fireball afterimage	28 sec	40 sec	89 sec

Calculations following the explosion indicated integrated fireball luminance to 100 microseconds was 4365 candles/cm^2/sec.

Severin (1961) performed an experiment in which four subjects were exposed to light flashes ranging over fire levels of luminance from 50 lumens/ft^2 to 5500 lumens/ft^2. Each flash had a duration of 0.15 seconds. Subjects then

TABLE I

Summary of Literature on Flash Effects

Laboratory Studies

	Source	Flash Intensity (Observer Position)	Exposure Time	Total Energy R'ced at Eye (Corneal Plane)
1.	Metcalf & Horn 1958	6.7 log ftL (0.05×10^8 mL)*	100 millisec	(5.2×10^5 mL-sec)
		(0.05×10^8 mL)	100 millisec	(5.2×10^5 mL-sec)
		(0.05×10^8 mL)	100 millisec	(5.2×10^5 mL-sec)
		(0.05×10^8 mL)	100 millisec	(5.2×10^5 mL-sec)
2.	Chisum & Hill 1961	(6.1×10^8 mL)	165 microsec	5 log mL-sec (1×10^5 mL-sec)
		(6.1×10^8 mL)	165 microsec	(1×10^5 mL-sec)
		(0.1×10^8 mL)	9.8 millisec	(1×10^5 mL-sec)
3.	Severin 1961	5500 lumens/ft^2 (5.9×10^3 mL)	150 millisec	(8.9×10^2 mL-sec)
		(5.9×10^3 mL)	150 millisec	(8.9×10^2 mL-sec)
4.	Severin, Newton & Culver 1962	232,000 lux (2.3×10^4 mL)	150 millisec	(3.5×10^3 mL-sec)
				Field Study
5.	Whiteside 1960	43650 c/cm^2 (1.37×10^8 mL)	100 millisec	4365 c/cm^2 (1.37×10^7 mL-sec)
		(1.37×10^8 mL)	100 millisec	(1.37×10^7 mL-sec)
		(1.37×10^8 mL)	100 millisec	(1.37×10^7 mL-sec)
		(1.37×10^8 mL)	100 millisec	(1.37×10^7 mL-sec)

*Numbers in parenthesis represent measures calculated or transformed for this table.

(TABLE I, Continued)

Pupil Diameter	Display Luminance (Visual Task)	Recovery Time	Visual Task
6 mm	71 ftL (76 mL)	5 sec	Respond correctly twice to test stimulus flashing at one-second intervals
	7 ftL (7.5 mL)	12 sec	7 ftL corresponds to flood-lighted aircraft instruments
	.45 ftL (.49 mL)	35 sec	.07 ftL corresponds to red-lighted aircraft instruments
	.07 ftL (.08 mL)	93 sec	
5 mm	2.25 log mL (180 mL)	2 sec	Determine orientation of acuity grating (reciprocal of visual angle in minutes = 0.33)
	1 mL	15 sec	
	1 mL	28 sec	
7-10 mm	.06 ftL (.06 mL)	13 sec	Respond correctly twice to test stimulus flashing at one-second intervals
	.013 ftL (.014 mL)	37 sec	
		10-50 secs for 16 subjs.	Respond correctly twice to test stimulus flashing at one-second intervals
Using Nuclear Burst			
4 mm	1.04 ftL (1.12 mL)	5 sec	Perceive a lighted square within a dark area (adaptometer)
	.41 ftL (.44 mL)	17 sec	
	.14 ftL (.15 mL)	58 sec	
	1.04 ftL (1.12 mL)	28 sec**	**This was viewed through the fireball after-image rather than foveally as in the other instances

All other values are from original reports.

viewed two patches of 0.06 and 0.013 foot-lamberts. Mean recovery times ranged from 0.6 seconds for the test patch brightness of 0.06 ftL and exposure of 50 lumens/ft^2 to 37.3 seconds for a test patch brightness of 0.013 ftL and exposure of 5500 lumens/ft^2.

The above study recently has been repeated and extended in scope (Severin, Newton & Culver, 1962). Sixteen subjects were used in this instance rather than four as previously. The purpose was to study the degree of inter-subject variability, the form of the recovery curve, and the effect of pupillary size upon recovery time. Again an exposure time of 150 milliseconds was used, although flash intensity was extended to a maximum of 21564 lumens/ft^2. The most impressive finding concerns inter-subject variability. For the maximum exposure, recovery times for the sixteen subjects ranged from 10 to 50 seconds. The authors state that "the individuality of the responses implies that healthy people vary considerably in their ability to handle the sensory overload of this situation."

Comparisons Among Experimental Studies

Five classic experiments have been described above, each of which investigated the effect of high intensity flashes on visual performance. The influence of target brightness (display luminance) upon visual recovery time following exposure also was investigated. Table 1 summarizes the procedures of these studies and the principal results in a manner designed to allow comparisons. It can be seen from Table 1 that a variety of exposure times, flash intensities, and other experimental conditions was used. In order to expedite those comparisons which can be made, all entries have been converted to a comparable set of units. Of all entries in this table, total energy received at the eye represents the most meaningful basis for comparison. Brown (1959) states that the total energy of an adapting flash up to several seconds in duration appears to be the critical variable in determining the shape of a dark adaptation curve.

There are a number of observations which can be drawn based on the data of Table 1. Those which appear most related to this discussion are:

1. Inconsistencies. There are certain inconsistencies apparent in the data. For example, in the experiment of Whiteside, the observer received more energy (1.37×10^7 mL-sec) than the subjects of Metcalf and Horn (5.3×10^5 mL-sec) for the same exposure time (100 millisec) and with a much darker target display (1.12 mL compared to 76 mL), yet both produced a visual recovery time of five seconds. Differences in the experimental procedures might well account for the observed discrepancy, one being a laboratory study and the other being a field study, or the difference might simply be due to differences in the basic visual mechanisms of the observers involved.

It is also possible that the discrepancy might be attributed to differences in the spectral distribution characteristics of the two sources. The carbon arc (Metcalf & Horn) is considered to be a reasonably good approximation of an atomic burst (Whiteside) in this respect.

2. Influence of Display Luminance. In four of the five experiments the brightness of the target display was varied. In every instance it can be seen that

increasing display luminance produces a substantial decrease in visual recovery time. For instance, in the study of Metcalf and Horn, with all other conditions held constant, an increase in display luminance from 0.07 ftL to 71 ftL produced a decrease in the required visual recovery time from 93 to 5 seconds.

3. Intensity/Time Reciprocity. Much early research in vision led to the conclusion that for fairly short exposure times there is a reciprocity between exposure time and brightness in determining the effect produced. Thus, the duration of flash blindness should depend on the product of brightness and time, or on the integrated brightness. The data of Table 1 indicated that, for extremely short exposure times, a strict reciprocity relationship does not exist. The data of Chisum and Hill indicate that, when total energy received at the eye is held constant, a decrease in exposure time from 9.8 milliseconds to 165 microseconds reduces recovery time from 28 to 15 seconds. A sixty-fold difference in duration for two flashes of equal total energy produces only about a two-fold difference in recovery time.

Probability of Foveal Exposure

The severity of visual damage, when occurring as a result of a nuclear flash, depends on whether the flash falls upon the foveal region or upon the periphery.

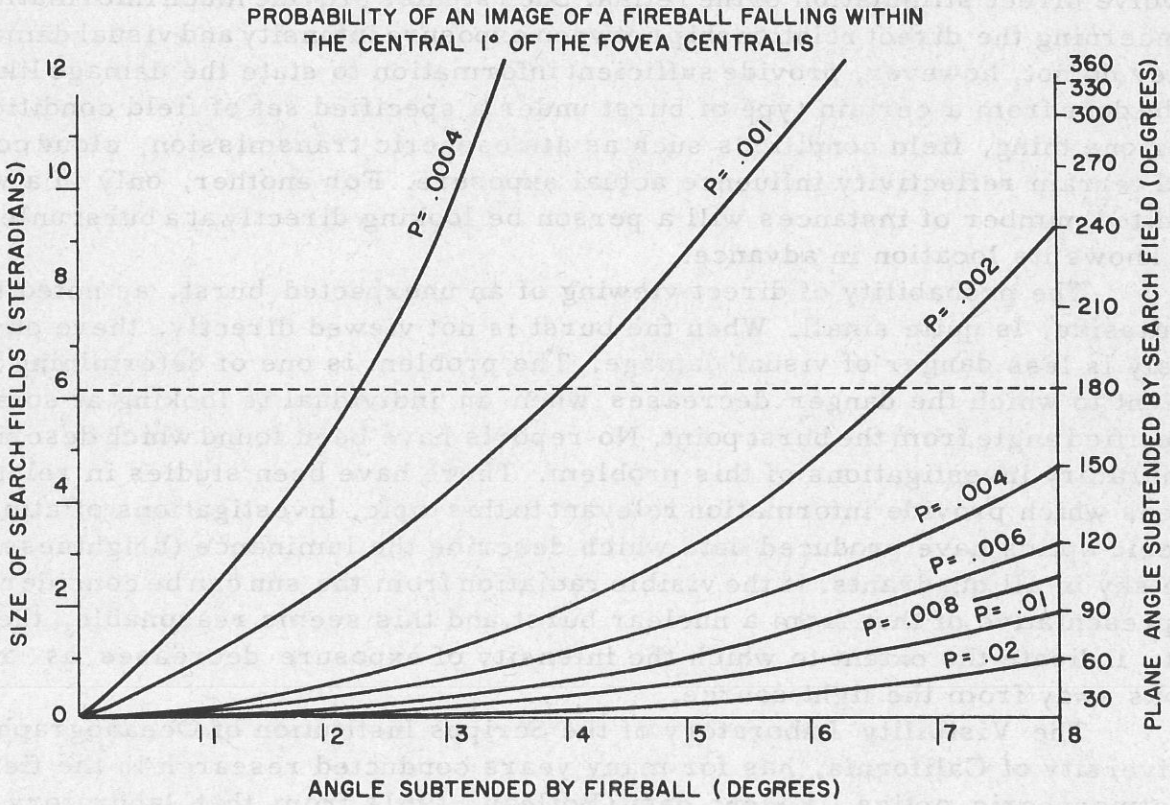

Fig. 3 Probability of focusing directly on fireball image during random search. (Whiteside, 1960)

Whiteside (1960) has computed the probability of a flash taking place directly in the line of sight of a pilot operating in a nuclear environment but not anticipating a burst. This is the probability of the image of the fireball being focused directly upon the foveal region. These calculations are based on the assumption that damage is done when some part of the image of a circular fireball overlaps onto the central 1 degree of the fovea. Figure 3 presents these possibilities. If the flash source is represented as a point in random positions, the probability of it falling in the 1 degree foveal field will be the percentage which the area of the foveal field bears to the area of the search field. When the size of the search field is 4 (pi) steradians, the flash may come from any direction. The unrestricted binocular field is estimated to be 1.5 steradians. It is evident from Figure 3 (page 37) that, even considering a small search field of 40 degrees in which the observer knows the explosion will occur, the likelihood of the flash taking place in the direct line of sight is quite small.

The low probability of direct foveal exposure strengthens the conclusion that the major problem faced, even in a nuclear environment, concerns flash blindness rather than retinal burns.

Effect of Viewing Angle on Exposure

Laboratory investigations of retinal burn damage and flash blindness invariably involve direct stimulation of the retina. Such studies provide much information concerning the direct relationship between exposure intensity and visual damage. They do not, however, provide sufficient information to state the damage likely to be done from a certain type of burst under a specified set of field conditions. For one thing, field conditions such as atmospheric transmission, cloud cover, and terrain reflectivity influence actual exposure. For another, only in a very limited number of instances will a person be looking directly at a burst unless he knows its location in advance.

The probability of direct viewing of an unexpected burst, as noted by Whiteside, is quite small. When the burst is not viewed directly, there obviously is less danger of visual damage. The problem is one of determining the extent to which the danger decreases when an individual is looking at some specified angle from the burst point. No reports have been found which describe laboratory investigations of this problem. There have been studies in related areas which provide information relevant to this topic. Investigations of atmospheric optics have produced data which describe the luminance (brightness) of the sky in all quadrants. If the visible radiation from the sun can be considered representative of that from a nuclear burst, and this seems reasonable, these data indicate the extent to which the intensity of exposure decreases as one looks away from the light source.

The Visibility Laboratory of the Scripps Institution of Oceanography, University of California, has for many years conducted research in the field of atmospheric optics. Recent data (Boileau, 1961) from that laboratory probably represent the best available information concerning luminance of the sky.

Effect of Azimuth Change From Source

The primary concern is with the extent to which exposure decreases as an individual looks away from the sun but maintains a constant scan angle above the horizon. Figure 4 presents data illustrating the changes which occur as the line of regard changes in azimuth from the sun. In this figure, all points represent measured values except that at the zero degree azimuth. This value, representing the brightness of the disc of the sun, was calculated by personnel of the Visibility Laboratory using atmospheric transmissivity measures taken on the day of this flight. In this instance, the altitude of the sun is 15 degrees. The altitude of the horizontal scan also is 15 degrees.

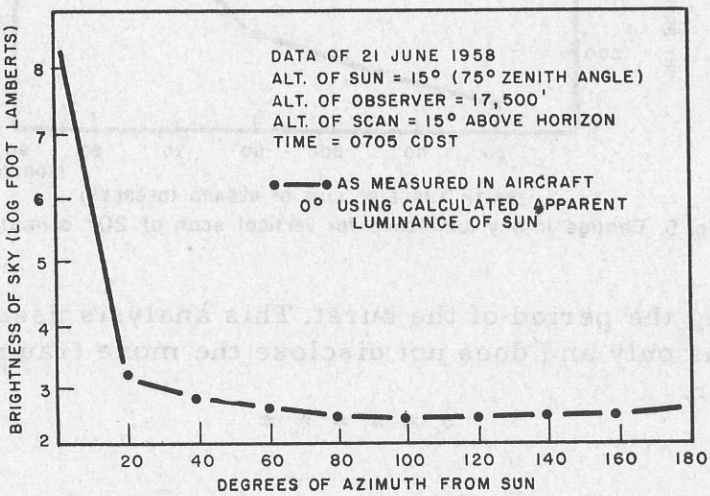

Fig. 4. Change in sky luminance as azimuth from sun changes.

Two observations can be made concerning Figure 4. First, the exposure one would receive from viewing the sky at an azimuth of 100 degrees from the sun is exceedingly small when compared to that which would be received through direct viewing of the sun. It is true that one would lose dark adaptation completely upon viewing of the sky, which was 340 foot lamberts in brightness, but there would be no period of flash blindness. The second observation relates to the rapidity of the decrease in exposure intensity with change in viewing angle. A change in viewing angle of only 20 degrees reduces the intensity of exposure to an acceptable level.

Effect of Elevation of Viewing Angle

The next question concerns the extent to which the intensity of exposure changes as one scans the sky vertically at a given azimuth angle from the sun. Figure 5 illustrates these changes at an azimuth angle of 20 degrees. It can be seen that the brightness of the sky changes from 220 ftL as a zenith angle of 30 degrees (60 degrees above the horizon) to a value of 2600 ftL at the horizon. This figure indicates that in this instance, the brightest part of the sky, regardless of proximity to the sun, is at the horizon. This analysis would seem to indicate that the chances of a person becoming flash blinded when exposed to a high intensity

source such as a nuclear burst are considerably less if he is not looking directly at the burst at the moment of detonation and if he can be trained not to look at

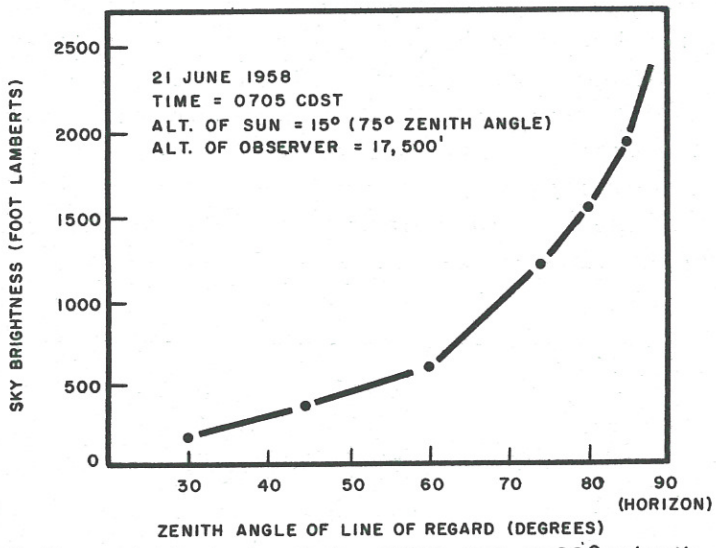

Fig. 5. Change in sky luminance for vertical scan at 20° azimuth.

the fireball during the period of the burst. This analysis uses data from clear weather conditions only and does not disclose the more traumatic incidents which might occur.

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